United States IOOS – Program Update

Zdenka S. Willis
Director, NOAA IOOS Program
1100 Wayne Ave, Suite 1225
Silver Spring, MD 20910 USA

Abstract- The United States Integrated Ocean Observing System (IOOS) is a user-driven, coordinated network of people, organizations, and technology that generate and disseminate continuous data about our coastal waters, Great Lakes, and oceans. IOOS is intended to be a major shift in approach to ocean observing, drawing together the vast network of disparate, federal and non-federal observing systems to produce a cohesive suite of data, information, and products at a sufficient geographic and temporal scale to support decision-making. As the system matures, IOOS is expected to advance beyond its current science and management applications toward an instrument of policy and governance. Current efforts only scratch the surface of what we need to know about our oceans and coasts to fully assess their impact on commerce and transportation, weather and climate, and ecosystems. The power of IOOS is in its partnerships. Seventeen United States federal agencies and eleven Regional Coastal Ocean Observing Systems (RCOOSs) share responsibility for the design, implementation, operation, and improvement of the United States. IOOS over time. Two interdependent components constitute the United State IOOS: (1) global ocean component and (2) coastal component. The latter includes the national set of observations for the Great Lakes and the EEZ, as well as the network of RCOOSs. Federal agencies are responsible for the design, operation, and improvement of both the global component and the national network of observations. RCOOSs augment existing federal observing capacity around the nation and ensure strong customer focus and connection. Each RCOOS, which is comprised of a series of sub-regional observing systems, is designed and managed by a single Regional Association (RA). Within the United States, an Integrated Ocean Observing System (IOOS) will enable the United States to make more effective use of existing resources, new knowledge, and advances in technology. The rapid growth in the number of people living in immediate proximity to the ocean is placing increased demand on coastal ecosystems, threatening their integrity and capacity to provide goods and services such as storm mitigation. This demographic trend is also placing an increasingly large segment of our society at risk to natural hazards.

Reducing risks from a broad range of threats associated with the oceans, including waterborne toxins, storm surge, coastal flooding, and unsafe marine transportation, depends on the ability to characterize and understand complex coastal-ocean phenomena, rapidly detect changes in the marine ecosystems and living resources, predict changes in our coastal-ocean environments, and adapt to these changes. NOAA continues to develop new approaches to ocean management to effectively address these challenges.

Thousands of data collection and management systems from satellites orbiting above the Earth to sensors trolling along the bottom of the ocean are gathering data. Many of these systems collect, distribute, and archive the same data (temperature, salinity, etc.) but in different ways. This disparity results in data that cannot be combined or analyzed together, are not easily accessible, and may never be known to exist. Consequently, time and resources are wasted converting disparate data and potentially duplicating data collections. Data from existing observing systems would be much more useful and timely if it were linked and presented in an integrated, standardized way.

The United States Integrated Ocean Observing System is our nation's contribution to the Global Ocean Observing System (GOOS)?the ocean component of a worldwide effort to build a Global Earth Observation System of Systems (GEOSS). The US IOOS is a national endeavor, comprising a coastal (national) and global component. The national coastal component includes both federal and regional contributions to monitor and manage the Great Lakes and the entire U.S. ocean environment.

I. INTRODUCTION

Within the United States, an Integrated Ocean Observing System (IOOS) will enable the United States to make more effective use of existing resources, new knowledge, and advances in technology. The rapid growth in the number of people living in immediate proximity to the ocean is placing increased demand on coastal ecosystems, threatening their integrity and capacity to provide goods and services such as storm mitigation. This demographic trend is also placing an increasingly large segment of our society at risk to natural hazards.

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According to the United States IOOS Development Plan, the process of linking observations to the development of useful, environmental information requires "a managed, efficient, two-way flow of data and information among three essential sub-systems." These sub-systems include:

- Measurement Data: Ocean observations collected from systems in the water, as well as land-based, airborne, or satellite platforms;

- Data Management and Communications (DMAC): The primary mechanism to integrate collected IOOS data so that they are compatible with one another and accessible to users; and

- Modeling and Analysis: Decision-support tools and services delivered to users, including related socio-economic research, outreach, training, and education.

Through these sub-systems, IOOS links observations decision-makers and other users to provide data and information needed to improve the nation’s ability to achieve seven societal goals:

- Improve predictions of climate change and weather and their effects on coastal communities and the nation;
- Improve the safety and efficiency of maritime operations;
- Allow more effective mitigation of the effects of natural hazards;
- Improve national and homeland security;
- Reduce public health risks;
- Protect and restore healthy coastal ecosystems more effectively;
- Enable the sustained use of ocean and coastal resources

II. GLOBAL COMPONENT

The global component of the United States Integrated Ocean Observing System (IOOS) initially began in 1990 and was led by the Intergovernmental Oceanographic Commission of UNESCO under the sponsorship of IOC/WMO/UNEP/ICSU. The implementation plan was adopted in 1992 to meet worldwide climate requirements. But this global ocean observing system also supports weather prediction, global and coastal ocean prediction, marine hazard warning systems (e.g., tsunami warning), transportation, marine environment and ecosystem monitoring, and naval applications. Although many impacts of climate variability are felt locally, climate is a global phenomenon. The United States is working to establish and sustain a global ocean observing system, so that the best possible information is available from which to initiate climate projections, and so that future generations will have the information necessary to resolve questions about long-term trends in climate.

Implementation of the *in situ* elements of the global ocean observing system is aimed at building and sustaining an observing system that will respond to the long-term observational requirements of the operational forecast centers, international research programs, and major scientific assessments. The primary objectives are to provide the observational basis for understanding and forecasting changes in sea surface temperature (e.g., El Niño), sea level, sea ice, ocean carbon sources and sinks, the ocean’s storage and global transport of heat and fresh water, and the ocean-atmosphere exchange of heat and fresh water. As technology develops, other ecosystem and living marine resource variables will be included.

Implementation of the *in situ* component global ocean observing system is managed by NOAA’s Climate Observation Division as 11 subsystems. A 12^{th} subsystem is Earth-observing satellites. The *in situ* elements are designed to work in concert with satellite capabilities. Each subsystem brings its unique strengths and limitations; together they build the whole; they are interdependent and must go forward together as a system. The subsystems are: Tide Gauge Stations, Surface Drifting Buoys, Tropical Moored Buoy, Network, Ships of Opportunity, Argo Profiling Floats, Ocean Reference Stations, Ocean Carbon

Networks, Arctic Ocean Observing Network, Dedicated Ships, Satellites, Data and Assimilation subsystems and Management and Product Delivery

There are presently 7723 *in situ* platforms maintained globally by the international community. NOAA supports 3860 of this total. The system is at present, however, just 60% complete, when compared to the initial design targets. These targets have been endorsed nationally by the CCSP and IOOS, and internationally by GOOS, GCOS, JCOMM, GEOSS, the WCRP, the UNFCCC, and the G8.

III. Coastal Component

The national coastal component includes both federal and regional contributions to monitor and manage the Great Lakes and the entire United States ocean environment. In February 2007, NOAA established a new program to serve as the overall coordinator NOAA's IOOS activities and to provide a consistent management function and to forward the national IOOS vision. The program's mission is to "Lead the integration of ocean, coastal, and Great Lakes observing capabilities, in collaboration with Federal and non-Federal partners, to maximize access to data and generation of information products, inform decision making, and promote economic, environmental, and social benefits to our nation and the world."

The NOAA IOOS Program is leading efforts to design, operate, and improve both the national and regional networks of ocean observations, including data management components, in partnership with 17 federal agencies. Regional capabilities are essential to building and supporting a national IOOS. They provide increased observation density, distinctive knowledge and technology competencies related to local environments, and an understanding of local user needs. The NOAA IOOS Program supports regional development across the spectrum of observations, data management, and modeling and analysis to support regional user needs while contributing to the national IOOS capability. This is done in partnership with 11 Regional Associations.

While the global component of GOOS and United States IOOS is delineated by programs, the coastal component of both GOOS and United States IOOS are defined in terms of common variables. The United States IOOS plan identified 20 core variables. In support of this mission, the NOAA IOOS program initiated development of a Data Integration Framework (DIF) to improve management and delivery of an initial subset of ocean observations. The DIF will establish the technical infrastructure, standards, and protocols needed to improve delivery of five of 20 IOOS core oceanographic variables. Integration efforts will focus on temperature, salinity, sea level, surface currents, and ocean color to improve NOAA's efforts to model and forecast harmful algal blooms, coastal inundation, hurricane intensity, and integrated ecosystem assessments. NOAA, by the end of the year will have integrated seven IOOS variables at three major data providers within NOAA. The two additional variables include winds and waves. Data providers at NOAA include the National Data Buoy Center (NDBC), Center for Operational Products and Services (CO-OPS) and Coastwatch. These data will be available in a consistent format across these data providers. The DIF is employing standard data content and schema that users can access through the OGC Web service. This represents a major achievement for NOAA. While internal and external partners used to solicit NOAA program data (i.e., program by program, collected according to program-specific standards), the IOOS DIF will enable access NOAA data irrespective of the Program of Office which collected

The success of a national IOOS depends on the development of a consistent data management infrastructure that will link observations to the data and information needs of multiple users at the global, national, regional, and state levels. Currently, there are few commonly accepted and applied standards for data format and transport, except for some specific applications. Consequently, data are not easily assembled from numerous diverse sources to meet the geographic coverage, vertical and horizontal resolution, accuracy, timeliness, and data processing needs of multiple ocean models, assessments, or other end users. Effectively linking a societal need for environmental information to observations will require an efficiently managed, two-way flow of data and information among the three IOOS "subsystems": observations, data management and communications (DMAC), and data analysis and modeling. These subsystems refer to necessary functions of IOOS, not organizational entities or physical components.

The NOAA IOOS Program is addressing these challenges of data consistency and interoperability through an interagency standards review process, established in October 2007 in accordance with the Ocean.US DMAC plan. This process will identify appropriate standards, best practices, and other protocols to establish a common foundation for integration. While initial efforts to design and build the DIF are limited in scope, the use of existing community standards and common data sharing infrastructure will facilitate extensibility to additional variables, data sources, and systems, as well as the larger IOOS community to build toward a national DMAC structure. To date 15 standards have been "submitted"; 4 have reached "proposed" status. While none have achieved "recommended" status yet as the process calls for a period of testing, this has been a very successful process since its inception.

Since data standards transcends any one nation, the United States (through NOAA IOOS Program) and the Government of Flanders (through the IOC Project Office for IODE) hosted the first session of the IOC's International Oceanographic Data and Information Exchange (IODE)/WMO Joint Commission for Oceanography and Marine Meteorology (JCOMM) Forum on Oceanographic Data Management and Exchange Standards. This was held January 21-25, 2008 at the IOC Project Office for IODE in Oostende, Belgium. The objective of this meeting was to get general agreement and commitment to adopt key standards related to ocean data management thereby facilitating exchange between oceanographic institutions.

IV. Industry Partnership

Industry has the capacity and expertise contribute to every aspect of IOOS development and operations and is considered critical to the longer-term success of the United States IOOS; however, resource constraints currently limit the feasibility of major industry involvement. In addition, United States IOOS efforts are still in a process of discovery with regard to the many technical challenges associated with IOOS development.

While not yet involved in a systematic manner, industry has served as an active partner in certain IOOS partnerships and provides value-added products and services. The NOAA Chesapeake Bay Interpretive Buoy System (CBIS) is one example. CBIS is the water counterpart to the United States Appalachian Trail, designed to mark significant points along the Captain John Smith Chesapeake National Historic Trail and to provide timely information about weather, oceanographic, and water quality along the way. This effort is the first of its kind, representing a large partnership among seven federal and non-federal entities and a number of industry representatives. The buoy, purchased from Axys Technologies, Inc., was mounted with a Nortek AS Acoustic Doppler Current Profiler (ADCP). NOAA worked with WET Labs, Inc. to develop an additional water quality instrument. Tellus Applied Sciences provided data management and web design support. Verizon wireless provided the data transmission, and Verizon Business system provides the data to voice conversion – a business application adapted for buoy use.

V. Conclusion

Just as in the international arena where the International GOOS program has both a global and coastal component, the United States IOOS also has global and coastal component. These two components are closely related and mutually dependent. Within NOAA there are two programs that spans the Coastal and the Global components, the NOAA IOOS Program and the Office of Climate Observations. We are linked programmatically and share office spaces to ensure that our United States IOOS program remains coordinated and that we participated in both the International GOOS and GCOS efforts which ultimately feed in to GEOSS.

While on one hand it is intuitive that the United States needs to be able to observe, monitor and predict conditions of our oceans, along our coasts and the Great Lakes. However we are continually being asked to provide the economic argument why we should invest in IOOS. Integrating ocean observations will safe lives. Observing is the foundation of understanding. Once we understand how our oceans power severe weather and natural hazards, we can then predict when such events will happen in the future. Earlier predictions of severe weather and natural hazards mean we can get more people to safety before disaster strikes. Ocean and coastal information is also important for understanding and predicting climate change and changes to our precious marine resources. Understanding the impacts of climate change on our coastal communities means we can better adapt and respond to changes such as sea level rise, coastal flooding, and rising temperatures.

IOOS is intended to be a major shift in approach to ocean observing, drawing together the vast network of disparate, federal and non-federal observing systems to produce a cohesive suite of data, information, and products at a sufficient geographic and temporal scale to support decision-making. As the system matures, IOOS is expected to advance beyond its current science and management applications toward an instrument of policy and governance. Current efforts only scratch the surface of what we need to know about our oceans and coasts to fully assess their impact on commerce and transportation, weather and climate, and ecosystems. Fortunately, given technological improvements in our ability to acquire, process, and analyze data, IOOS is possible *now*.